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Assessment of attenuation processes in a chlorinated ethene plume by use of stream bed Passive Flux Meters, streambed Point Velocity Probes and contaminant mass balances

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Chlorinated ethenes (CE) are abundant groundwater contaminants and pose risk to both groundwater and surface water bodies, as plumes can migrate through aquifers to streams. After release to the environment, CE may undergo attenuation. The hyporheic zone is believed to enhance CE attenuation, however studies contradicting this have also been reported. Since dilution commonly reduces contaminant concentrations in streams to below quantification limits, use of mass balances along the pathway from groundwater to stream is unusual.

Our study is conducted at the low-land Grindsted stream, Denmark, which is impacted by a contaminant plume. CE have been observed in the stream water; hence our study site provides an unusual opportunity to study attenuation processes in a CE plume as it migrates through the groundwater at the stream bank, through the stream bed and further to the point of fully mixed conditions in the stream.

The study undertook the determination of redox conditions and CE distribution from bank to stream; streambed contaminant flux estimation using streambed Passive Flux Meters (sPFM); and quantification of streambed water fluxes using temperature profiling and streambed Point Velocity Probes (SBPVP). The advantage of the sPFM is that it directly measures the contaminant flux without the need for water samples, while the advantage of the SBPVP is its ability to measure the vertical seepage velocity without the need for additional geological parameters. Finally, a mass balance assessment along the plume pathway was conducted to account for any losses or accumulations.

The results showed consistencies in spatial patterns between redox conditions and extent of dechlorination; between contaminant fluxes from sPFM and concentrations from water samples; and between seepage velocities from SBPVP and temperature-based water fluxes. Mass balances and daughter-to-mother compound ratios indicated limited degradation between the bank and the point of fully mixed stream water. Since the plume at the bank mainly consists of cis-DCE and vinyl chloride, this implies high and persistent stream water concentrations of these compounds. Finally, this study demonstrates the usefulness and complementary nature of sPFM and SBPVP measurements for assessing the attenuation processes through mass balance calculations.